SPECIFICATION

NWS-R435-PR-SP001

for a

DOPPLER WEATHER RADAR SYSTEM

1 JULY 2000

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1.0 SCOPE

This document establishes the performance, and test requirements of a Doppler weather radar system.

2.0 APPLICABLE DOCUMENTS

This section lists all the applicable documents referenced elsewhere in this Specification. The current issue of the following documents, together with their first tier references, form a part of this Specification. Unless specifically stated otherwise, the version of the document that applies is the version in effect on the date of issue of the solicitation.

2.1 Documents

The following documents are available from the sources shown.

a. Department of Commerce

WSR-88D System Specification	Specification Number 2810000B CAGE Identification Code 0WY55 November 18, 1997
Interface Control Document for the Radar Data Acquisition (RDA) to Open Radar Product Generation (ORPG)	Document Number 2620002C CAGE Identification Code 0WY55 WSR-88D OSF June 26, 1999
Volume Coverage Patterns (VCP)Description WSR-88D	Document Number 282003A,PT1 Code Identification 0WY55 WSR-88D OSF, 26 June 1998 Build 10.0 Appendix IV: RDA Volume Coverage Patterns
Velocity De-aliasing Description	Document Number 282003A,PT1 Code Identification 0WY55 WSR-88D OSF, 26 June 1998 Build 10.0 Appendix II: Computer Program Development Specification for Radar Product Generation Program

Source: Operational Support Facility
3200 Marshall Avenue
Norman, OK 73072
Attn: Systems Support Branch
405-366-6540 x3231

National Telecommunications and Information Administration (NTIA) Manual of Regulation and Procedures for Federal Radio Frequency Management (May, 1997)

Source: U.S. Department of Commerce
National Telecommunications and Information Administration
HCHB Building
14 Constitution Ave, NW
Washington, DC 20230

Internet Address:

http://www.ntia.doc.gov/osmhome/redbook/redbook.html

National Weather Service (NWS) Susceptibility Standard (May 1978)

Source: National Weather Service, W/OSO323
1325 East-West Highway
Silver Spring, MD 20910
301-713-1839 x177

b. Federal Aviation Administration

AC 70/7460-IK FAA Advisory Circular, Obstruction Marking and Lighting

Source: Federal Aviation Administration
Washington, DC 20591

Internet Address:

http://www.faa.gov/ats/ata/circular/om/home.htm

c. Department of Defense

MIL-HDBK 419A	Grounding, Bonding, and Shielding for Electronic Equipment and Facilities
MIL-HDBK-454	General Guidelines for Electronic Equipment
MIL-STD-188-124B	Grounding, Bonding, and Shielding
MIL-STD-461E	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment

Source: Defense Automation and Production Service
Building 4/D
700 Robbins Avenue
Philadelphia, PA 19111-5094

Internet Address:

http://astimage.daps.dla.mil/quicksearch

d. Electronic Industry Alliance

EIA EMCB 9	Filtering, Electronic Equipment

Source: Global Engineering Documents
15 Inverness Way East
Englewood, CO 80112
1-800-854-7179

Internet Address:

http://global.ihs.com/

e. National Electric Code (NEC)

Source: NFPA
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9101
617-770-0700
Internet Address:

http://www.nfpa.org/

2.2 Paragraph Referencing

When sections or paragraphs are referenced herein, all subordinate sections or paragraphs to those references shall apply.

3.0 REQUIREMENTS

This section delineates the engineering and performance requirements for a Doppler weather radar system. All requirements of this Specification and its Appendices shall be levied by the Contractor on Subcontractors and Vendors, as applicable, to ensure the delivered system meets the requirements of this Specification.

3.1 System Definition

The NWS has a requirement to acquire a Doppler weather radar system to mitigate an area of inadequate coverage identified within the present Next Generation Weather Radar (NEXRAD) Network.

The Doppler weather radar system shall use the same data acquisition schemes and produce data compatible with the NWS WSR-88D. The Doppler weather radar system shall provide coverage of a specific geographical area from a Government selected site. The system shall function as a self-contained, stand-alone radar with data acquisition, signal processing and meteorological display capability.

A radar base data output interface shall be required. This interface shall supply a Government NEXRAD meteorological processor with radar base data. By supplying radar base data output to a Government NEXRAD meteorological processor, the stand-alone radar will be integrated into the WSR-88D Network as a shared resource. The functionality of the radar shall be in compliance with the requirements of this Specification. The system shall have an operational service life of twenty (20) years.

3.2 System Description

The Doppler weather radar system shall be a 10cm (S-band) weather radar having a beamwidth of one degree and minimum meteorological signal detection capability of -7 dBZ_e at 50km, with radar pulsewidth of 1.6µs, and -15 dBZ_e with a radar pulsewidth of 4.5µs. The radar shall deliver estimates of normalized reflectivity, radial velocity, and spectrum width on a polar grid at azimuth increments of 0.5 or 1 degree, and range increments of 250 meters, 500 meters, and 1 km to a range of 230 km for velocity, and a range of 460 km for reflectivity.

This meteorological data, as well as auxiliary support data and radar control data, shall be remoted to terminals at a Weather Forecast Office (WFO). A radar control terminal and meteorological display terminal shall be required.

This radar is not intended to be a development project, but rather a currently available commercial radar that may require minimal modification. The only development work is the addition of a communications interface to supply radar base data for the NEXRAD network.

3.3 System Requirements

The system requirements of the Doppler weather radar system [1]shall be as defined in Table 3-1. Numbers [#] contained in brackets refer to requirement numbers in Test Verification Matrix Table 4.1.

TABLE 3-1 System Requirements

Type	Meteorological Doppler
[1a] Frequency Band	2700 MHz to 3000 MHz
[1b] Modulation - pulsed	J = 1.6 µs J = 4.5 µs
[1c] Minimum Detection Capability (Signal to noise ratio of 0 dB)	J = 1.6 µs # -7 dBZ_e at 50km, [0 = $0.47(10^{-12})m^2/m^3$] J = 4.5 µs # -15 dBZ_e at 50km, [0 = $0.06(10^{-12})m^2/m^3$]

3.4 Functional Requirements

Functionally, the weather radar is divided into five subsystems including the radar acquisition system; radar remote control terminal; meteorological remote display terminal; communications interface; and radar facilities.

3.4.1 Radar Acquisition System

The radar acquisition system consists of the site components, including tower, radome, antenna, pedestal, transmitter, receiver, signal processor with signal interconnections and power wiring. The radar acquisition system provides base data acquisition.

The radar acquisition system shall be capable of operating under the environmental conditions described in section 3.8.8.

3.4.1.1 Power Source

The radar facility [2]shall be capable of operating with both commercial and auxiliary power as defined in Table 3-2.

TABLE 3-2 Power Requirements

[2a] Commercial Power Operational Tolerance	Voltage = 3N,120/208 VAC +/-10% Frequency = 60Hz +/- 5%
[2b] Auxiliary Power (Contractor supplied)	Voltage = 3N,120/208 VAC +/-10% Frequency = 60Hz +/- 5%. Minimum full load run time of 168 hrs

The power quality shall be regulated and conditioned to maintain the voltage and frequency limits required to support the operational availability requirements of section 3.9. The auxiliary power shall be capable of providing the radar sufficient power with no detectable degradation of service. The auxiliary power [2c]shall self initiate upon sensed loss of power. The transfer of power [2d]shall maintain the voltage and frequency limits required to support the operational availability requirements of section 3.9 and create no loss of data from the radar.

3.4.1.2 Tower

The tower [3]shall meet the requirements of Table 3-3.

TABLE 3-3 Tower Requirements

Height to base of pedestal	# 30m (To Be Determined)
[3a]Survival without damage	Winds # 60 m/sec sustained wind measured at the maximum height of the tower
[3b]Maximum twist or sway	< 0.1 degrees at winds # 50 m/sec from any direction

3.4.1.3 Radome

The Radome [4]shall meet the requirements of Table 3-4.

TABLE 3-4 Radome Requirements

[4a]Surface	Hydrophobic surface
[4b]Rain Performance	Excess two way attenuation of wet radome is # 1 dB
[4c]Survival without damage	55 m/sec sustained winds from any direction 80 m/sec gust

3.4.1.4 Antenna

The antenna pattern [5]shall have the characteristics defined in Table 3-5.

TABLE 3-5 Antenna Characteristics

[5a]Type	Single Pencil Beam $0.9 < 2_3/N_3 < 1.1$
[5b]Half-power beamwidth	# 1 degree, 2.7GHz < f_0 < 3GHz
[5c]Sidelobe range	**Minimum** 1st side lobe # -25 dB 2 deg < |N,2| < 12 deg taper $ .75 dB/deg, |N,2| > 12 deg all sidelobes < -34 dB **Maximum** 1st side lobe # -25 dB 2 deg < |N,2| < 10 deg taper $ 1.0 dB/deg, |N,2| > 10 deg running average of sidelobes < -40 dB
[5d]Polarization	Linear horizontal
[5e]Beam pointing accuracy	Error # 0.15 deg absolute (including boresight error)

3.4.1.5 Pedestal

The pedestal [6]shall meet the requirements of Table 3-6.

TABLE 3-6 Pedestal Requirements

[6a]Type	Elevation over Azimuth
[6b]Steerability	Continuous 360 degrees in azimuth -1 deg to +60 deg in elevation
[6c]Rotation rate	Variable; 0 deg/sec to 30 deg/sec in azimuth and elevation
[6d]Acceleration	$15 deg/sec^2 in azimuth and elevation
[6e]Deceleration	$ 15 deg/sec^2 in azimuth and elevation
[6f]Positioning error	# 0.2 deg in azimuth and elevation including angular encoding precision

3.4.1.6 Transmitter

The transmitter [7]shall meet the requirements of Table 3-7.

TABLE 3-7 Transmitter Requirements

[7a]Type	Coherent pulse to pulse
[7b]Frequency band	2700 MHz to 3000 MHz
[7c]Frequency accuracy/Aging	0.0005% at 25 deg C/year
[7d]Frequency stability	0.0005% for 0° < Temperature < 50°C
[7e]Operational frequency	Government assigned
[7f]3 dB Pulse width	1.6µs, 4.5µs
[7g]Radio frequency emission	Compliant with NTIA section 5.5.4, criteria D
[7h]Phase noise	< -53 dBc integrated over the Nyquist co-interval
[7i]Pulse repetition frequency repertoire (Minimum)	322 Hz, 446 Hz, 644 Hz, 857 Hz 1014 Hz, 1095 Hz, 1181 Hz, 1282 Hz
[7j]Pulse train	Contiguous, staggered, batch

3.4.1.7 Receiver

The receiver [8]shall meet requirements of Table 3-8.

TABLE 3-8 Receiver Requirements

Type	Coherent linear
[8a]Dynamic range	$ 90 dB (noise level to 1 dB compression)
[8b]Phase noise	< -53 dBc integrated over the Nyquist co-interval

3.4.1.8 Output Data

Data output and statistics [9]shall meet the requirements of Table 3-9.

TABLE 3-9 Output Data

[9a]Output data format	Available in 0.5 deg azimuth Available in 1.0 deg azimuth Selectable between both increments with precision less than 0.05 degrees for all parameters 250m and 500m range increments for velocity 1000m range increments for reflectivity Range coverage of 230 km for velocity and 460 km for reflectivity with a range accuracy better than 0.1%
[9b]Reflectivity	Unbiased (Standard deviation < 1 dB*)
[9c]Velocity	Unbiased for Gaussian spectra (Standard deviation < 1 m/sec*)
[9d]Spectrum width	Unbiased for Gaussian spectra (Standard deviation < 1 m/sec*)
*Calculate or measure base data standard deviation under the conditions of Gaussian input spectra with standard deviation (width) of 4 m/sec, signal to noise ratio > 10 dB, Nyquist velocity of 25 m/sec, and estimate dwell time of 42 msec.	

3.4.1.9 Ground Clutter Suppression

The system [10]shall be capable of providing the following level of ground clutter suppression as defined in Table 3-10.

TABLE 3-10 Ground Clutter Suppression

Minimum of Three Suppression Levels **3 dB NOTCH HALFWIDTH**	**Suppression (In clutter regimes having standard deviation less than 0.28 m/sec)** **LEVEL**
< 1 m/sec	> 20 dB
< 2 m/sec	> 30 dB
< 3 m/sec	> 45 dB

3.5 Radar Remote Control Terminal

The remote radar control terminal located at the WFO serves as the forecaster's interface to the radar. The remote radar control terminal provides radar system control, radar system status monitoring, and signal processing control. A radar control terminal local to the radar acquisition system shall be supplied for maintenance.

3.5.1 Radar System Control

The remote terminal [11]shall provide, as a minimum, the following capabilities:

[11a] - Transmitter On-off

[11b] - Transmitter (Radiate) On-Off

[11c] - Antenna Drive On-Off

[11d] - System On-Off

[11e] - Transmitter pulse width select

[11f] - System fault master reset

3.5.2 Data Acquisition Control - Radar Parameters

The Radar shall provide a minimum capability of eight distinct volume coverage patterns (VCP), four of which shall be delivered with the system. The volume coverage patterns [12] shall contain the following parameters:

[12a] - Transmitter PRF

[12b] - Transmitter pulse train

[12c] - Azimuth scan rate

[12d] - Azimuth scan direction

[12e] - Elevation position

[12f] - Transmitter pulse width

The following four volume coverage patterns (VCP) [13]shall be delivered with the radar. The radar system shall provide the Government with the capability to program the additional four VCPs. Table 3-11a gives the Pulse repetition frequency (PRF) as called out in the required four scan strategies. Table 3-11b supplies the Pulse train type (PT) as called out in the required four scan strategies.

[13a]TABLE 3-11a

PRF Description

PRF No.	FREQUENCY
1	322Hz
2	446Hz
3	644Hz
4	857Hz
5	1014Hz
6	1095Hz
7	1181Hz
8	1282Hz

[13b]TABLE 3-11b

Pulse Train Description

PULSE TRAIN	MODE
CS	Continuous Surveillance
CD	Continuous Doppler

B	Batch

[13c]TABLE 3-11c Scan Strategy 1

Volume Coverage Pattern 11 Short Pulse

Scan				Surveillance		Doppler PRF Number				
Elevation (Deg)	AZ Rate (Deg/s)	Period (Sec)	PT Type	PRF	No. Pulses	[4] No. Pulses	[5] No. Pulses*	[6] No. Pulses*	[7] No. Pulses*	[8] No. Pulses
0.5	18.675	19.38	CS	1	17	-	-	-	-	-
0.5	19.224	18.83	CD	-	-	44	52	56	61	66
1.45	19.844	18.24	CS	1	16	-	-	-	-	-
1.45	19.225	18.83	CD	-	-	44	52	56	61	66
2.4	16.116	22.46	B	1	6	35	41	43	46	50
3.35	17.893	20.23	B	2	6	35	41	43	46	50
4.3	17.898	20.23	B	2	6	35	41	43	46	50
5.25	17.459	20.73	B	3	10	35	41	43	46	50
6.2	17.466	20.73	B	3	10	35	41	43	46	50
7.5	25.168	14.38	CD	-	-	34	41	43	46	50
8.7	25.398	14.25	CD	-	-	33	41	43	46	50
10.0	25.421	14.24	CD	-	-	33	41	43	46	50
12.0	25.464	14.22	CD	-	-	33	41	43	46	50
14.0	25.515	14.19	CD	-	-	33	41	43	46	50
16.7	25.596	14.14	CD	-	-	33	41	43	46	50
19.5	25.696	14.09	CD	-	-	33	41	43	46	50
* Default Doppler PRF numbers are underscored										

[13d]TABLE 3-11d Scan Strategy 2

Volume Coverage Pattern 21 Short Pulse

Scan				Surveillance		Doppler PRF Number				
Elevation (Deg)	AZ RATE (Deg/s)	Period (Sec)	PT Type	PRF	No Pulses	[4] No. Pulse	[5] No. Pulses*	[6] No. Pulses	[7] No. Pulses*	[8] No. Pulse
0.5	11.339	31.92	CS	1	28	-	-	-	-	-
0.5	11.360	31.87	CD	-	-	75	88	95	103	111
1.45	11.339	31.92	CS	1	28	-	-	-	-	-
1.45	11.360	31.86	CD	-	-	75	88	95	103	111
2.4	11.180	32.38	B	2	8	59	70	76	82	88
3.35	11.182	32.37	B	2	8	59	70	76	82	88
4.3	11.185	32.36	B	2	8	59	70	76	82	88
6.0	11.189	32.35	B	3	12	59	70	76	82	88
9.9	14.260	25.39	CD	-	-	59	70	76	82	88
14.6	14.322	25.27	CD	-	-	59	70	76	82	88
19.5	14.415	25.11	CD	-	-	59	70	76	82	88
* Default Doppler PRF numbers are underscored										

[13e]TABLE 3-11e Scan Strategy 3
Volume Coverage Pattern 31 Long Pulse

SCAN			PRF		
Elevation (Deg)	Rate (Deg/s)	Period (Sec)	PT Type	PRF No.	No. Pulses
0.05	5.039	71.83	CS	1	63
0.50	5.061	71.52	CD	2	87
1.50	5.040	71.82	CS	1	63
1.50	5.062	71.52	CD	2	87
2.50	5.041	71.81	CS	1	63
2.50	5.062	71.50	CD	2	87
3.50	5.063	71.49	CD	2	87
4.50	5.065	71.47	CD	2	87

[13f]TABLE 3-11f Scan Strategy 4
Volume Coverage Pattern 32 Short Pulse

Scan						Surveillance	Doppler PRF Number			
Elevation (Deg)	AZ Rate (Deg/s)	Period (Sec)	PT Type	PRF No.	No Pulses	[4] No. Pulse	[5] No. Pulses*	[6] No. Pulses	[7] No. Pulses	[8] No. Pulses
0.50	4.961	72.97	CS	1	64	-	-	-	-	-
0.50	4.544	79.66	CD	-	-	188	220	238	256	278
1.50	4.961	72.96	CS	1	64	-	-	-	-	-
1.50	4.544	79.66	CD	-	-	188	220	238	256	278
2.50	4.060	89.15	B	2	11	188	220	238	256	278
3.50	4.061	89.13	B	2	11	188	220	238	256	278

4.50	4.063	89.10	B	2	11	188	<u>220</u>	238	256	278
* Default Doppler PRF numbers are underscored										

3.5.3 Signal Processing Acquisition Control

Signal processing parameter selection [14]shall be operator selectable by data fields and consist of the following:

[14a] - Azimuth sample increment

[14b] - Range gate increment

[14c] - Number of range gates

[14d] - Signal to noise thresholds

3.5.4 Clutter Suppression Control

The following clutter suppression controls [15]shall be provided:

[15a] - Clutter filter selection	On - Off
[15b] - Filter notch half-width velocity (½ m/sec to 4 m/sec in 1/4 m/sec increments)	Selection
[15c] - Filter under map control	Selection
[15d] - Forced filtering range	Selection

3.5.5 Radar System Status Monitoring

As a minimum, the following radar status conditions [16]shall be provided on the Radar System and displayed for the operator via the remote radar control terminal:

[16a] - High Voltage

[16b] - Modulator current

[16c] - Klystron air flow

[16d] - Klystron Filament Voltage

[16e] - Klystron Filament Current

[16f] - Klystron Power (Forward/Reverse)

[16g] - Klystron Peak Current

[16h] - Waveguide Arc

[16i] - Transmitter PRF

[16j] - RF Drive Level

[16k] - Transmitter Pulse Width

[16l] - Low Voltage Power supplies

[16m] - Security/Fire Alarms

[16n] - All Faults - listed by item

[16o] - All Interlocks

[16p] - Local/Remote Control (Primary control by site)

[16q] - Azimuth Position

[16r] - Elevation Position

[16s] - Azimuth Drive

[16t] - Elevation Drive

3.5.6 System Verification

The following outlines the areas and functionality of the required testing and diagnostics. Variations in the organization, execution, and level of testing are acceptable provided the overall monitoring is sufficient for the operator to determine system status for operational purposes.

System verification [17]shall be available to provide the operator with an overall indication of the system status. These diagnostic checks [18]shall be executable from the local and remote control terminals. These checks are divided into the following groups:

[18a] Radar Built in Test Equipment (BITE) Data

[18b] Antenna Control Verification

[18c] Signal Processor Verification

The current status of all test results [19]shall be displayed for the operator via the remote radar control terminal. A 24-hour system status log [20]shall be maintained to provide a historical record of system performance.

3.5.6.1 Radar BITE Data

BITE data shall be utilized by the operator to determine the system operating condition and to help determine if maintenance is required. Currently available BITE data shall be listed for the transmitter, receiver, and antenna. BITE data such as described in 3-12 [21]shall be displayed on the remote radar control terminal for the operator to see.

3.5.6.2 Antenna Control Verification

In addition to antenna BITE data, a capability [22]shall be provided for the operator to enter either an antenna rotation rate of less than or equal to 30 degrees/second or an antenna position command and verify the antenna's response.

3.5.7 Signal Processor Verification

Reflectivity and velocity calculations shall be verified by insertion of test signals having known values and by determining how those values relate to delivered results.

3.5.7.1 Reflectivity Calibration Verification

A method for verifying calibration of the radar [23]shall be provided. This function shall include the following:

[23a] A method of signal injection at a minimum of three power levels spanning the receiver dynamic range, using a controllable signal generator at one injection point prior to the LNA.

[23b] The capability for the operator to access radar parameters pertinent to the reflectivity calculation including but not limited to antenna gain and beamwidth. The transmitter power, transmitter and receiver losses, and system noise level are to be made available through lookup or measurement.

[23c] A method of evaluating calibration data such as comparison of test signal predicted to radar measured reflectivity by using a test set.

3.5.7.2 Velocity Calculation Verification

A method of verifying the velocity calculation [24]shall be provided. This function shall include the following:

[24a] A method of known frequency (±0.1%) analog signal injection prior to the A/D converter.

[24b] A method of evaluating the calculation such as comparison of test signal predicted velocity to signal calculated velocity.

3.5.8 System Diagnostics

System diagnostics are divided into the following groups:

a. Radar Noise Power

b. Antenna Diagnostics

c. Signal Processor Diagnostics

d. BITE Diagnostics

e. Communications Loop-Back Tests

3.5.8.1 Radar Noise Power

The system [25]shall provide a measure of radar receiver noise power, noise figure, or noise temperature.

3.5.8.2 Signal Processor Diagnostics

The signal processor shall perform diagnostics [26]testing of the following areas:

[26a] Memory tests

[26b] Analog-to-digital converter tests

Two modes of testing [26c]shall be provided including a fixed parameter default test, and an interactive test. In the default test mode the parameters are fixed, and [26d]shall provide a pass/fail indication when implemented. In the interactive test mode, the operator [26e]shall have the capability of entering signal processor supplied parameters for evaluation. In both test modes, the results [26f]shall be displayed on the terminal screen.

3.5.8.3 BITE Diagnostics

BITE diagnostics [27a]shall provide the capability to monitor all radar system functions measured in an operations mode. BITE [27b]shall also verify control and read-back functions. Table 3-12 states the desired BITE diagnostics.

[27a]TABLE 3-12 BITE Diagnostics

TRANSMITTER* (*Based on Klystron)	**RECEIVER**	**ANTENNA PEDESTAL**
Filament voltage and current	IF fidelity	Azimuth output drive
Beam PS voltage and current	Video fidelity	Elevation output drive
RF drive	Automatic gain control level	Azimuth antenna position
Temperature	Low voltage power supplies	Elevation antenna position
Low voltage power supplies	Forward power	Low voltage power supplies
Oil level	Reverse power	Azimuth drive on/off
Airflow	I raw sample	Elevation drive on/off
Beam PRF	Q raw sample	Elevation tachometer
RF pulse width	I processed sample	Azimuth tachometer
RF pulse repetition frequency	Q processed sample	Antenna elevation limit indicators
Ion pump voltage and current		Azimuth and elevation servo input errors
Over current and voltage modes		Power on/off
Waveguide arc		Radome temperature
Interlocks (If applicable)		Air flow
Local/Remote		
System triggers		

3.5.8.4 Communications Loop-Back Tests

A communications loop-back test capability [28a]shall be provided. This test shall provide a means of evaluating the quality of data transmission between the remote radar control terminal and the radar acquisition system. The test [28b]shall, as a minimum, compare a series of transmitted and returned bit patterns and shall record all differences which require corrective action or analysis.

3.5.8.5 Communication Lines

The Government will supply both wideband and narrowband communication lines in accordance with the Doppler weather radar system requirements.

3.5.9 Archiving

An archive capability [29a]shall be provided that includes a permanent and easily transportable recording medium such as hard disk or 1600 bpi tape. The archive function as a minimum, [29b]shall be capable of storing digital base data, and status information. The archiving function [29c]shall include a playback capability on the remote radar control terminal. The Doppler weather radar system [29d]shall have the capability of ingesting previously recorded data from the archive system.

Archive data [29e]shall include date, time, azimuth and elevation data, and radar status data. Date [29f]shall be Modified Julian Date (1970), and time [29g]shall be Zulu time.

3.5.10 Hard Copy Capability (Printer)

System hardware [30]shall as a minimum, include a color printer to print data on 8.5" x 11" plain paper at a minimum rate of five color pages per minute. The radar system shall have the capability to print any displayable screen from either the remote control terminal or the meteorological terminal.

3.6 Meteorological Display Terminal

A data display terminal located remotely at the Weather Forecast Office (WFO) [31]shall be provided. The terminal shall ingest intensity, velocity, and spectrum width data, generate products, and provide display of base data and meteorological analysis products.

At the WFO normalized reflectivity, velocity, and spectrum width base data [32a]shall be displayed as a continuous 360 degree azimuth sweep. Data [32b]shall be available as polar products for all elevation angles of the volume coverage pattern. The base products [32c]shall as a minimum, meet the requirements and provide the capabilities as defined in Table 3-13.

[32c]TABLE 3-13 Base Product Functionality

BASE PRODUCT	RESOLUTION	DATA LEVELS	MAX RANGE
Reflectivity(Z)	1 km - 1 deg 2 km - 1 deg 4 km - 1 deg 1 km - 1 deg 2 km - 1 deg 4 km - 1 deg	8 8 8 16 16 16	230 Km 460 Km 460 Km 230 Km 460 Km 460 Km
Mean Radial Velocity Products (V)	250 m - 1 deg 500 m - 1 deg 1 km - 1 deg 250 m - 1 deg 500 m - 1 deg 1 km - 1 deg	8 8 8 16 16 16	60 Km 115 Km 230 Km 60 Km 115 Km 230 Km
Spectrum Width (SW)	250 m - 1 deg 500 m - 1 deg 1 km - 1 deg	8 8 8	60 Km 115 Km 230 Km

3.6.1 Velocity De-aliasing/Echo Obscuration

The velocity [33a]shall be de-aliased over at least two Nyquist co-intervals.

a. Minimal performance would entail schemes such as the dual PRF operating on adjacent azimuthal radials.

b. Maximum performance is the Eilts scheme described in the WSR-88D document #282003A, PT1. The Government will provide this code.

Regions in which multi-trip echos are overlaid [33b]shall be identified in both displayed and archived data.

a. Minimal performance is identification of obscured areas at the PRF in use with an operator selectable threshold variable from 5 dB to 20 dB in 5 dB steps.

b. Maximum performance is the above plus computation and reporting of the PRF (from choices available) having the minimum obscured area.

3.7 Communications System

The communications system [34a]shall provide for the transfer of all communications to include radar control, base data, and housekeeping. The Government will furnish as required the wideband and narrowband communication lines between the radar acquisition

system and the WFO in accordance with the radar communications

requirements. System bandwidth [34b]shall be sufficient for data transfer with the radar operating at maximum antenna speed, and any combination of data acquisition parameters (see section 3.5.2).

3.8 Radar Facilities

Radar facilities include the shelters and tower, and installed equipment, such as power generation and air conditioning equipment to support the radar. Included are the tower, radome, antenna, pedestal, transmitter, receiver, and signal processor.

The construction of the radar site shall be in accordance with the requirements of: Appendix B Site Preparation Requirements;
Appendix C Electrical Specification;
Appendix D Concrete Specification; and
Appendix E Fence Specification.

3.8.1 Space

Workspace around equipment shall meet the requirements of NEC article 110.

3.8.2 Power

Power requirements are defined in section 3.4.1.1.

3.8.3 Lighting

Radome lighting [35]shall meet the requirements of AC 70/7460-1K, FAA Advisory Circular, Obstruction Marking and Lighting. Otherwise, the radar facility shall not require any special lighting effects other than incandescent lighting.

3.8.4 Direct Burial Cables

Cables used in an outdoor environment [36a]shall be designed for direct earth burial and installed according to the requirements of article 300-5 of the National Electric Code (NEC), and [36b]shall be armored to be gopher resistant. The cable shielding, grounding, and routing [36c]shall be in accordance with subsections 5.1, 5.2, and 5.3 of MILS-STD-188-124B, using the guidelines of MIL-HDBK-419A.

3.8.4.1 Electromagnetic Emissions and Susceptibility Limits

Limits [37]shall meet the requirements of NWS Transient Susceptibility Standard (May 1978) as follows:

a. AC Powerline Transients [37a]shall meet the requirements of Test Level I, with acceptance criteria 3.3(b) in both common and transverse mode.

b. Signal Line Transients [37b]shall comply with acceptance criteria 3.3(b). Crosstalk per 4.3.1; lightning effects per 4.3.2 in both common and transverse mode.

c. Static discharge criteria [37c]shall be 7.5KV, 50 pulses, both controlled and uncontrolled.

3.8.4.2 Susceptibility

The susceptibility (conducted) requirements of MIL-STD-461E [38a]shall be as defined in Table 3-14.

[38a]TABLE 3-14 Susceptibility (conducted) Requirements

	APPLICABLE SPECIFICATION	RANGE OF REQUIREMENTS
ALL POWER LINES	CS101 CS116	30 HZ to 150 kHz 10 kHz to 100 MHz
ANTENNA TERMINALS	CS103 CS104 CS105	Intermodulation, two signals Residual of undesired signals Cross modulation

The susceptibility (radiated) requirements of MIL-STD-461E [38b]shall be as defined in Table 3-15.

[38b]TABLE 3-15 Susceptibility (radiated) Requirements

	APPLICABLE SPECIFICATION	RANGE OF REQUIREMENTS
MAGNETIC FIELD	RS101	30 Hz to 100 kHz
ELECTRIC FIELD	RS103	2 MHz to 40 GHz
ELECTROMAGNETIC FIELD	RS105	Transient, EM field

The guidelines for attenuation requirements, selection of suppression components, and mechanical considerations as described by the Filtering, Electronic Equipment, EIA EMCB 9 [38c]shall be used.

3.8.5 Internal and External Cableways

Cableways [39]shall be in accordance with (NEC) Article 318 requirements, and electromagnetic interference requirements described in subsection 5.3 of MIL-STD-188-124B.

3.8.6 Grounding

The radar equipment [40a]shall operate with a facility grounding system whose resistance complies with the NEC. The grounding connections and grounding methods [40b]shall be as required in paragraph 5.1.1 of MIL-STD-188-124B, using the guidelines of MIL-HDBK-419A. The resistance of the radar equipment to earth [40c]shall be 10 ohms or less.

3.8.7 Lightning Protection

Lightning protection devices [41]shall be installed in accordance with MIL-STD-188-124B, paragraph 5.1.1.3, using the guidelines of MIL-HDBK-419A, Volume I, Chapter 1, and Volume II, Chapter 3.

3.8.8 Environmental Conditions

The Doppler weather radar system shall be capable of operating in and withstanding the environmental conditions specified below.

3.8.8.1 Temperature and Humidity

The shelters shall maintain an internal temperature and humidity range as required by the operating temperature and humidity range of the individual sheltered equipment. The shelters and the equipment external to the shelters shall maintain full functionality in the outdoor environment as specified in 3.8.8.1.1.

3.8.8.1.1 Outdoor Environment

All equipment comprising the Doppler weather radar acquisition system [42]shall meet the following requirements:

Condition	Temperature	Humidity
Operating	-40 Deg C (Min) +49 Deg C (Max)	15 - 100%
Nonoperating	-62 Deg C (Min) +60 Deg C (Max)	15 - 100%

3.8.8.1.2 Indoor Environment

In an operating condition, the shelters that house the radar equipment [43]shall provide and maintain an operating environment compliant with the equipment requirements and specifications in regard to temperature and humidity. However, as a minimum, the

operating/nonoperating conditions of all equipment comprising the Doppler weather radar acquisition system shall meet the following requirements:

Condition	Temperature	Humidity
Nonoperating	-35 Deg C (Min) +60 Deg C (Max)	15 - 100%

3.8.8.2 Solar Radiation

Exposed (See Note 1) Doppler weather radar acquisition system equipment [44]shall be capable of withstanding, without failure, the following intensities of ultraviolet, visible, and infrared radiation:

Spectrum Portion	Wavelength (Microns)	Intensities [W/ft^2](Note 2) [W/m^2] (Note 3)	Percent of Total
Ultraviolet	< 0.38	75.35 [7] or less	7 or less
Visible	0.38 - 0.78	538.20 [50] or less	48 or less
Infrared	> 0.78	775.0 [72] or less	69 or less

Note 1. Exposed equipment is that equipment not normally located in a controlled environment, including but not limited to, radomes, towers, and shelters.

Note 2. W/ft^2 = Watts per square foot

Note 3. W/m^2 = Watts per square meter

3.8.8.3 Rainfall

Exposed Doppler weather radar acquisition system equipment [45]shall be operable and sustain no physical damage when subjected to wind and rain under the following conditions:

a. Operational - An instantaneous rain rate equivalent to 300 mm per hour with a maximum wind speed of 18 m/s; and

b. Nonoperational

(1) A 1-hour average rain rate of 130 mm per hour (with an instantaneous rate of 400 mm per hour) at a wind speed of 33 m/s;

(2) A 12-hour average rain rate of 30 mm per hour at a wind speed of 26 m/s; and

(3) A 24-hour average rain rate of 18 mm per hour with a wind speed of 21 m/s.

3.8.8.4 Fungus

Exposed Doppler weather radar acquisition system equipment shall be compliant with Guideline 4 (Fungus-Inert Materials) of MIL-HDBK-454.

3.8.8.5 Salt Fog

Exposed Doppler weather radar acquisition system equipment shall be capable of continuous operation in a salt laden atmosphere. Material surfaces shall be resistant to degradation.

3.8.8.6 Sand and Dust

All system capabilities shall be met when exposed Doppler weather radar acquisition system equipment has been subjected to the effects of blowing fine sand and dust particles at wind speeds of up to 18 m/s , and a particle concentration of 0.177 grams per cubic meter with particle sizes up to 150 micrometers in diameter.

3.8.8.7 Snow and Ice Load

Exposed Doppler weather radar acquisition system equipment [46]shall sustain no physical damage when subjected to 235 kilograms per square meter of snow and ice loading.

3.9 Operational Availability

Operational availability (A_o) is defined as the probability that, when used under stated conditions, a system shall operate as specified at any given time. For the Doppler weather radar system, the operational availability for full system operation without any degradation [47]shall be 96% as defined below. The required response time to arrive onsite shall be three hours.

Specifically, A_o is derived from the following formula:

$$A_o = \frac{OT + ST}{OT + ST + TPM + TCM + ALDT} = \frac{\text{Operational Time}}{\text{Total Time}}$$

Where:

OT = Operating time per calendar year
ST = Standby time
TPM = Total preventive maintenance time per calendar year
TCM = Total corrective maintenance time per calendar year
ALDT = Administrative and logistics delay time spent waiting for parts, maintenance personnel, or transportation per calendar year

3.9.1 Reliability

System reliability is defined as the probability that a system shall perform as specified for a given period of time when used under specified operating conditions. The radar system reliability shall be expressed in terms of a Mean Time Between Failure (MTBF).

By definition, MTBF is calculated using the following formula:

$$\text{MTBF} = \frac{\text{Total mission time}}{\text{Number of failures}}$$

For the Doppler weather radar system, the system MTBF requirement is directly related to the operational availability requirement.

3.10 Interface to the NEXRAD Meteorological Processor

An interface shall provide radar base data in accordance with the format as specified in Appendix A. The Government will integrate the formatted output of the Doppler weather radar system into the WSR-88D radar system network.

The interface port [48a]shall be located at the WFO and shall be connected using an RJ 45 or equivalent connector to Government equipment via a TCP/IP LAN-based connection. The Government will be responsible for all equipment and communications from the interface port forward. The Government will input the radar base data from the interface port into the NEXRAD meteorological processor which will be located at the WFO.

The NEXRAD meteorological processor will remain in a passive mode and will process data as data is supplied. The NEXRAD radar remote control meteorological processor will not control the radar. (The Contractor supplied radar remote control data and terminal shall continue to control the radar.) The format of the interface data supplied by the interface port [48b]shall comply with Appendix A.

4.0 QUALITY ASSURANCE

This section establishes the test and evaluation (T&E) requirements and provides guidance for verification methods and techniques for the Doppler weather radar system. T&E shall be conducted to verify each of the identified requirements (reference Verification Matrix provided in Table 4.1).

4.1 Scope of Test and Evaluation

Quality assurance shall include, component testing, system testing, acceptance testing, and interface developmental test and evaluation as identified in Table 4-1, Test Verification Matrix. System testing is done at the factory and acceptance testing is done onsite.

4.2 Factory Component Testing

Component testing is the testing done at a subassembly or assembly level prior to the integration into the system or other higher level assemblies. This testing shall verify design and validate the incorporation of a component into the system.

4.2.1 Certificate of Compliance (C of C)

A C of C is a document or several documents certifying that capabilities stated for component equipment meet specified requirements. These are used when testing or evaluating is impractical or cost prohibitive. Sufficient supporting documentation shall be made available.

Certificates shall be required on several components including the shelters' ability to provide and maintain an operating environment compliant with equipment requirements and with regard to the outdoor environment range of temperature and humidity (see section 3.8.8.1).

4.3 Factory System Testing

System testing verifies compliance with system objectives where qualified and integrated hardware and software subsystems are tested as a complete system. The system test shall test system programming, functionality, system interfaces, verify that system performance requirements have been met, and verify that the system is stable. Functionality tests at the system test level shall include, but is not limited to, the requirements contained in section 3.5, valid and invalid data input (error handling), and the radar operator's manual procedure validation. Factory system testing shall be completed prior to shipment from the factory.

4.3.1 Factory Functional Area Interface Tests

Functional area interface tests shall be performed to demonstrate that the design of the functional areas of the Doppler weather radar system are compatible and that they interface properly. Communications functional area performance tests shall be conducted to verify that all requirements of this document are met under full load conditions. Full

load conditions shall be represented by utilizing VCP 11 with a 50% range coverage. Functional area interface testing shall include communications testing to verify that the radar requirements have been satisfied.

4.3.2 Factory System Requirement Tests

System level performance tests shall be conducted under full load conditions to demonstrate the system level performance requirements have been met, how well it operates when various faults are introduced, and how well the system handles stressful operating loads. The demonstration of system level performance by a combination of test, simulation and analysis is permitted.

4.3.3 Factory Radar System Control Testing

The remote radar control terminal shall be located with the meteorological display terminal at the WFO. Tests shall be performed which demonstrate that the design and functionality of these components comply with the requirements contained in section 3.5 during factory and acceptance testing.

4.3.4 Factory Interface Developmental Testing and Evaluation (DT&E)

DT&E is required for the development of the NEXRAD meteorological processor radar base data interface port requirement of section 3.10. This interface shall comply with Appendix A.

DT&E testing shall be used to track progress and verify that compliance to Appendix A has been established. DT&E is formal testing that covers all functional areas altered or augmented by this interface requirement. DT&E shall consist of hardware and software development testing and evaluation.

Testing the development of the NEXRAD meteorological processor interface port shall be defined in a separate test plan identifying DT&E milestones.

4.4 Onsite Acceptance Testing

Acceptance testing is T&E which evaluates the operational effectiveness and suitability of the Doppler weather radar system in its operational environment and verifies the system is stable over time.

4.4.1 Onsite System Testing

System testing verifies compliance with system objectives. Fully qualified and integrated hardware and software subsystems shall be tested as a complete system. The system test shall test the system programming and functionality, verify system performance requirements have been met, and verify the system is stable over time.

4.4.1.1 Onsite Functional Area Interface Testing

Functional area interface tests shall be performed which demonstrate that the design of the functional areas of the Doppler weather radar system are compatible and that they interface properly. Communications functional area performance tests shall be conducted to verify that all requirements of this document are met under full load conditions. Full load conditions shall be represented by utilizing VCP 11 with a 50% range coverage.

Functional area interface testing shall include communications testing to verify that the radar requirements have been satisfied.

4.4.1.2 Onsite System Requirement Testing

System level performance tests shall be conducted under full load conditions to demonstrate the system level performance requirements have been met, how well it operates when various faults are introduced, and how well the system handles stressful operating loads. The demonstration of system level performance by a combination of test, simulation and analysis is permitted.

4.4.1.3 Onsite Radar System Control Testing

The remote radar control terminal shall be located with the meteorological display terminal at the WFO. Tests shall be performed which demonstrate that the design and functionality of the radar control terminal comply with the requirements contained in section 3.5.

4.4.1.4 Onsite Stability Testing

A stability test [49]shall be conducted exercising operational functions of the radar under normal operating conditions. Operator control of the radar shall be exercised and shall include the archiving of data. The stability test shall demonstrate the system is stable over a 72-hour continuous run without errors or failures.

4.4.1.5 Onsite Environmental Demonstration

Environmental testing shall be based upon the manufacturer's detailed environmental testing data and requirements for continuous equipment operation. The shelters that house the Doppler weather radar equipment shall provide and maintain an operating environment compliant with equipment requirements and specifications in regard to temperature and humidity.

4.4.2 Onsite Interface Acceptance Testing and Evaluation

As part of acceptance, the radar base data interface port requirement shall be verified to be compliant with section 3.10 and Appendix A. The onsite testing shall be used to verify compliance to Appendix A and that the interface port functions correctly at the WFO location.

4.4.3 Onsite Final Acceptance Testing

The supplied Doppler weather radar system shall be accepted when all the requirements of the Test Verification Matrix Table 4.1 have been verified. This testing shall include the final 72-hour stability test as called for in section 4.5.1.4.

TABLE 4-1 Test Verification Matrix

* This column is intentionally left blank.		VERIFICATION METHOD Legend: NA – Not Applicable 1 – Analysis 2 – Demonstration 3 – Examination 4 – Test/Measurement 5 - C of C (Certificate of Compliance)						VERIFICATION TECHNIQUE Legend: NA – Not Applicable 1 - Component Testing 2 - Integration Testing 3 – System Testing 4 – Acceptance Testing (Acceptance testing shall be performed onsite)				
Specification Requirement	Referenced Section	NA	1	2	3	4	5	NA	1	2*	3	4
1a System	3.3						x				x	
1b	3.3					x					x	
1c	3.3		x			x					x	
2a Power	3.4.1.1			x								x
2b	3.4.1.1			x								x
2c	3.4.1.1			x								x
2d	3.4.1.1			x		x						x
3a Tower	3.4.1.2						x					x
3b	3.4.1.2						x					x
4a Radome	3.4.1.3						x		x			
4b	3.4.1.3					x			x			
4c	3.4.1.3						x		x			
5a Antenna	3.4.1.4		x			x			x			
5b	3.4.1.4		x			x			x			
5c	3.4.1.4		x			x			x			
5d	3.4.1.4				x				x			
5e	3.4.1.4		x			x			x		x	x
6a Pedestal	3.4.1.5				x						x	
6b	3.4.1.5			x							x	x
6c	3.4.1.5					x					x	x
6d	3.4.1.5					x					x	x
6e	3.4.1.5					x					x	x

* This column is intentionally left blank.		VERIFICATION METHOD Legend: NA – Not Applicable 1 – Analysis 2 – Demonstration 3 – Examination 4 – Test/Measurement 5 - C of C (Certificate of Compliance)						VERIFICATION TECHNIQUE Legend: NA – Not Applicable 1 - Component Testing 2 - Integration Testing 3 – System Testing 4 – Acceptance Testing (Acceptance testing shall be performed onsite)				
Specification Requirement	Referenced Section	NA	1	2	3	4	5	NA	1	2*	3	4
6f	3.4.1.5					x					x	x
7a Transmitter	3.4.1.6					x					x	
7b	3.4.1.6					x					x	
7c	3.4.1.6					x					x	
7d	3.4.1.6						x				x	
7e	3.4.1.6					x					x	
7f	3.4.1.6					x					x	
7g	3.4.1.6					x					x	x
7h	3.4.1.6		x			x					x	x
7i	3.4.1.6					x					x	
7j	3.4.1.6					x					x	
8a Receiver	3.4.1.7					x					x	x
8b	3.4.1.7		x			x					x	x
9a Output Data	3.4.1.8					x					x	x
9b	3.4.1.8		x								x	
9c	3.4.1.8		x								x	
9d	3.4.1.8		x								x	
10 Clutter Suppression	3.4.1.9		x			x					x	x
11a Radar Control	3.5.1			x							x	x
11b	3.5.1			x							x	x
11c	3.5.1			x							x	x
11d	3.5.1			x							x	x
11e	3.5.1			x							x	x

TABLE 4.1 Test Verification Matrix (cont.)

* This column is intentionally left blank.		VERIFICATION METHOD Legend: NA – Not Applicable 1 – Analysis 2 – Demonstration 3 – Examination 4 – Test/Measurement 5 - C of C (Certificate of Compliance)						VERIFICATION TECHNIQUE Legend: NA – Not Applicable 1 - Component Testing 2 - Integration Testing 3 – System Testing 4 – Acceptance Testing (Acceptance testing shall be performed onsite)				
Specification Requirement	Referenced Section	NA	1	2	3	4	5	NA	1	2*	3	4
11f	3.5.1			x							x	x
12a Data Acquisition	3.5.2			x							x	x
12b	3.5.2			x							x	x
12c	3.5.2			x							x	x
12d	3.5.2			x							x	x
12e	3.5.2			x							x	x
12f	3.5.2			x							x	x
13a PRF	3.5.2					x					x	
13b Pulse Train	3.5.2					x					x	
13c Scan Patterns	3.5.2			x		x					x	x
13d	3.5.2			x		x					x	x
13e	3.5.2			x		x					x	x
13f	3.5.2			x		x					x	x
14a Signal Processing Control	3.5.3					x					x	x
14b	3.5.3					x					x	x
14c	3.5.3					x					x	x
14d	3.5.3					x					x	x
15a Clutter Suppression Control	3.5.4					x					x	x
15b	3.5.4					x					x	x
15c	3.5.4					x					x	x
15d	3.5.4					x					x	x

TABLE 4.1 Test Verification Matrix (cont.)

* This column is intentionally left blank.		VERIFICATION METHOD Legend: NA – Not Applicable 1 – Analysis 2 – Demonstration 3 – Examination 4 – Test/Measurement 5 - C of C (Certificate of Compliance)						VERIFICATION TECHNIQUE Legend: NA – Not Applicable 1 - Component Testing 2 - Integration Testing 3 – System Testing 4 – Acceptance Testing (Acceptance testing shall be performed onsite)				
Specification Requirement	Referenced Section	NA	1	2	3	4	5	NA	1	2*	3	4
16a System Status Monitoring	3.5.5		x								x	x
16b	3.5.5		x								x	x
16c	3.5.5		x								x	x
16d	3.5.5		x								x	x
16e	3.5.5		x								x	x
16f	3.5.5		x								x	x
16g	3.5.5		x								x	x
16h	3.5.5		x								x	x
16i	3.5.5		x								x	x
16j	3.5.5		x								x	x
16k	3.5.5		x								x	x
16l	3.5.5		x								x	x
16m	3.5.5		x								x	x
16n	3.5.5		x								x	x
16o	3.5.5		x								x	x
16p	3.5.5		x								x	x
16q	3.5.5		x								x	x
16r	3.5.5		x								x	x
16s	3.5.5		x								x	x
16t	3.5.5		x								x	x
17 System Verification	3.5.6			x							x	x
18a System Checks	3.5.6			x							x	x

TABLE 4.1 Test Verification Matrix (cont.)

* This column is intentionally left blank.		VERIFICATION METHOD Legend: NA – Not Applicable 1 – Analysis 2 – Demonstration 3 – Examination 4 – Test/Measurement 5 - C of C (Certificate of Compliance)						VERIFICATION TECHNIQUE Legend: NA – Not Applicable 1 - Component Testing 2 - Integration Testing 3 – System Testing 4 – Acceptance Testing (Acceptance testing shall be performed onsite)				
Specification Requirement	Referenced Section	NA	1	2	3	4	5	NA	1	2*	3	4
18b	3.5.6			x							x	x
18c	3.5.6			x							x	x
19 System Status	3.5.6			x							x	x
20 System Status Log	3.5.6			x							x	x
21 BITE Data	3.5.6.1			x							x	x
22 Antenna Control Testing	3.5.6.2			x							x	x
23a Reflectivity Calibration	3.5.7.1			x							x	x
23b	3.5.7.1			x							x	x
23c	3.5.7.1			x							x	x
24a Velocity Calculation Test	3.5.7.2		x	x							x	x
24b	3.5.7.2		x	x							x	x
25 Receiver Noise	3.5.8.1					x					x	x
26a Signal Processor Diagnostics	3.5.8.2			x							x	x
26b	3.5.8.2			x							x	x
26c	3.5.8.2			x							x	x
26d	3.5.8.2			x							x	x
26e	3.5.8.2			x							x	x
26f	3.5.8.2			x							x	x

TABLE 4.1 Test Verification Matrix (cont.)

* This column is intentionally left blank.		VERIFICATION METHOD Legend: NA – Not Applicable 1 – Analysis 2 – Demonstration 3 – Examination 4 – Test/Measurement 5 - C of C (Certificate of Compliance)						VERIFICATION TECHNIQUE Legend: NA – Not Applicable 1 - Component Testing 2 - Integration Testing 3 – System Testing 4 – Acceptance Testing (Acceptance testing shall be performed onsite)				
Specification Requirement	Referenced Section	NA	1	2	3	4	5	NA	1	2*	3	4
27a BITE Diagnostics	3.5.8.3			x	x						x	x
27b	3.5.8.3			x	x						x	x
28a Communication Loop –Back Test	3.5.8.4			x							x	x
28b	3.5.8.4					x					x	x
29a Archiving	3.5.9			x							x	x
29b	3.5.9			x							x	x
29c	3.5.9			x							x	x
29d	3.5.9			x							x	x
29e	3.5.9			x	x						x	x
29f	3.5.9			x	x						x	x
29g	3.5.9			x	x						x	x
30 Printer	3.5.10			x							x	x
31 Display Terminal	3.6			x							x	x
32a	3.6			x							x	x
32b	3.6			x							x	x
32c	3.6			x							x	x
33a Velocity De-aliasing	3.6.1			x		x					x	x
33b	3.6.1			x		x					x	x
34a Communications	3.7			x							x	x
34b	3.7					x					x	x

TABLE 4.1 Test Verification Matrix (cont.)

* This column is intentionally left blank.		VERIFICATION METHOD Legend: NA – Not Applicable 1 – Analysis 2 – Demonstration 3 – Examination 4 – Test/Measurement 5 - C of C (Certificate of Compliance)						VERIFICATION TECHNIQUE Legend: NA – Not Applicable 1 - Component Testing 2 - Integration Testing 3 – System Testing 4 – Acceptance Testing (Acceptance testing shall be performed onsite)				
Specification Requirement	Referenced Section	NA	1	2	3	4	5	NA	1	2*	3	4
35 Lighting	3.8.3				x						x	x
36a Cabling	3.8.4						x					x
36b	3.8.4						x					x
36c	3.8.4				x							x
37a Electromagnetic Emissions and Susceptibility	3.8.4.1						x					x
37b	3.8.4.1						x					x
37c	3.8.4.1						x					x
38a Susceptibility	3.8.4.3						x					x
38b	3.8.4.3						x					x
38c	3.8.4.3						x					x
39 Cableways	3.8.5				x						x	x
40a Grounding	3.8.6						x					x
40b	3.8.6						x					x
40c	3.8.6						x					x
41 Lightening	3.8.7				x							x
42 Outdoor Environment	3.8.8.1.1						x					x
43 Indoor Environment	3.8.8.1.2						x					x
44 Solar Radiation	3.8.8.2						x					x
45 Rainfall	3.8.8.3						x					x
46 Snow and Ice	3.8.8.7						x					x

TABLE 4.1 Test Verification Matrix (cont.)

* This column is intentionally left blank.		VERIFICATION METHOD Legend: NA – Not Applicable 1 – Analysis 2 – Demonstration 3 – Examination 4 – Test/Measurement 5 - C of C (Certificate of Compliance)						VERIFICATION TECHNIQUE Legend: NA – Not Applicable 1 - Component Testing 2 - Integration Testing 3 – System Testing 4 – Acceptance Testing (Acceptance testing shall be performed onsite)				
Specification Requirement	Referenced Section	NA	1	2	3	4	5	NA	1	2*	3	4
47 Availability	3.9						x	x				
48a Communications Interface					x							x
48b						x	x				x	x
49 (72-hour) Stability				x								x

TABLE 4.1 Test Verification Matrix (cont.)

5.0 GLOSSARY

Aliasing: The process by which frequencies too high to be analyzed with the given sampling interval appear at a frequency less than the Nyquist frequency.

Azimuth: A direction in terms of the 360 degree compass.

Base Data: Those digital fields of reflectivity, mean radial velocity, and spectrum width data.

Base Products: Those products that present some representation of the base data. This representation may not necessarily be either in full resolution or depict the full area of coverage. Base products can be used to generate a graphic display or further processing.

Batch Pulse Train: A series of two groups of pulses with one fixed interval between pulses in one group and a second fixed interval between pulses for the other group.

Clutter: Echoes that interfere with observation of desired signals on a radar display. Usually applied to ground targets.

Coherent Radar: A radar that utilizes both signal phase and amplitude to determine target characteristics.

Contiguous Pulse Train: A series of equal spaced pulses

Data Resolution: The resolution of base data as provided by the signal processor, nominally 0.54nmi(1 km) x 1°(AZ) x 1°(EL) for reflectivity values and 0.13nmi(0.25km) x 1°(AZ) x 1°(EL) for velocity values.

Decibel(dB): A logarithmic expression for ratio of two quantities. The dBm is a decibel with respect to 1 milliwatt.

$$dB = 10 \text{ Log } (P_1/P_2)$$
$$dBm = 10 \text{ Log } (P/10^{-3})$$
$$dBZ = 10 \text{ Log } (Z_e)$$

Dynamic Range: The ratio, usually expressed in decibels, of the maximum to the minimum signal that a system can handle. Used to describe the limits of receivers.

Eilts scheme: A Doppler velocity de-aliasing algorithm that processes one radial at a time by comparing that radial with a previous radial.

Elevation Angle: The vertical pointing angle of the antenna.

Equivalent Radar Reflectivity (Z_e): The concentration of uniformly distributed small (diameter of one sixteenth wavelength or less) water particles that would return the amount of power received. $dBZ = 10 \text{ Log } Z_e$ (typically).

Frequency: The number of recurrences of a periodic phenomenon per unit time. Electromagnetic energy is usually specified in Hertz (Hz), which is a unit of frequency equal to one cycle per second.

Frequency Carrier (f_o): For the WSR-88D, the fundamental transmitted microwave frequency between 2,700 and 3,000 megahertz. It is modulated so it exits for a few microseconds each pulse repetition time. This limit is called the transmitted pulse.

Gating (Range Gating): The use of electronic circuits in radar to eliminate or discard the target signals from all targets falling outside certain desired range limits.

Ground Clutter: The pattern of radar echoes from fixed ground targets.

Half-Power Beamwidth: Angular width of the mainlobe at the half-power level.

Hydrophobic Surface: A surface that has the ability to shed water efficiently

Increment: Distance between adjacent samples

Klystron: An electron tube used as a low-power oscillator or a high-power amplifier at ultrahigh frequencies. Noted for exceptional stability over long periods of transmission.

Mainlobe: The envelope of electromagnetic energy along the main axis of the beam.

Mean Doppler Velocity(Mean Radial Velocity): Reflectivity-weighted average velocity of targets in a given volume sample. Usually determined from a large number of successive pulses. Also called mean radial velocity. Doppler velocity usually refers to spectral density first moment; radial velocity to base data.

Modulation: Variation of the amplitude, frequency, or phase of a wave due to the mixing of two signals.

Notch Width: The 3 dB bandwidth of a rejection filter.

Notch Halfwidth: Distance from zero to 3 dB response of rejection filter

Nyquist Co-interval: The frequency interval between $-f_s/2$ and $+f_s/2$

Nyquist Frequency: The highest frequency that can be determined in data that have been discretely sampled. For data sampled at frequency f_s, this frequency is $\pm f_s/2$.

Operational Mode: A combination of one or more volume coverage patterns and product mixes tailored to one or more meteorological situations.

Pulse (pulsed) Radar: A type of radar, designed to facilitate range measurement, in which the transmitted energy is emitted in periodic brief transmissions.

Pulse Repetition Frequency (PRF): The number of pulses transmitted per second.

Pulse Repetition Time (PRT): The pulse interval from the beginning of one pulse to the beginning of the next pulse.

Pulse Width: The time occupied by an individual broadcast from a radar.

Radial Velocity: The component of motion of the target toward or away from the radar, i.e., the projection of target motion on the radial unit vector

Range Gate Increment: Distance between two adjacent range samples.

Reflectivity: The measure of the efficiency of a target in intercepting and returning radio energy. In the case of hydrometers it is a function of the drop size distribution, number of particles per unit volume, physical state (ice or water), shape, and aspect.

Sidelobe: Secondary radiated energy maximum other than radar main beam. Typically contains a small percentage of energy compared to the mainlobe.

Signal-to-Noise Ratio (SNR): A ratio that measures the comprehensibility of data, usually expressed as the signal power divided by the noise power.

Spectrum Width: A measure of dispersion of velocities within the radar sample volume.

Staggered Pulse Train: A series of pulses in which the interval between pulses changes from pair to pair.

Standard Deviation: The positive square root of the signal variance. In the WSR-88D, the velocity standard deviation is called spectrum width.

Transmitter: The equipment used for generating and amplifying a radio frequency (rf) carrier signal, modulating the carrier signal with intelligence, and feeding the modulated carrier to an antenna for radiation into space as electromagnetic waves.

Unambiguous Range: The range to which a transmitted pulse can travel and return to the radar before the next pulse is transmitted.

Velocity Aliasing: Ambiguous detection of radial velocities outside the Nyquist co-interval.

Volume Coverage Pattern: A volumetric sampling procedure designed for the surveillance of one or more particular meteorological phenomena.

Volume Scan: The process of completing a series of specified scans in a specific sequence.

WSR-88D Unit: A WSR-88D Unit is composed of a Doppler weather radar, computers, work stations, and communications to link the components and distribute the products.

Symbols:

Ze	**=**	Equivalent reflectivity
J	=	Pulse width
0	=	Volume reflectivity
2_3	=	Antenna mainlobe half power (-3 dB) width in horizontal plane
N_3	=	Antenna mainlobe half power (-3 dB) width in vertical plane
dBc	=	Phase noise power relative to carrier power in dB
f_o	=	Frequency Carrier
I	=	In-phase component of the complex signal
Q	=	Quadrature component of the complex signal
[#]	=	Numbers contained in brackets refer to requirement numbers in Test Verification Matrix